

January 8, 2014



Hand-Delivered

Mr. Darrell Nitschke
ND Public Service Commission
600 E. Boulevard
Dept. 408
Bismarck, ND 58504-0480

Re: Border Winds Energy Project, Rolette County, North Dakota
Case No. PU-08-797

Dear Mr. Nitschke:

Enclosed is an original and 10 copies of the following:

1. Petition for Modification or Amendment of Findings of Fact, Conclusions of Law, and Order Granting Certificate of Site Compatibility with Attachments 1 – 3; and
2. Joint Application of Sequoia Energy US, Inc. and Border Winds Energy, LLC for Transfer of Certificate of Site Compatibility for Energy Conversion Facility.

If you have any questions, please feel free to contact Dante Tomassoni at 701.221.8606.
Thank you.

Sincerely,

STINSON LEONARD STREET LLP



Corrina Pfaff
LAA/Paralegal

CP:cp
Enclosures

89 PU-08-797 Filed 01/08/2014 Pages: 45
Petition for modification or amendment of Findings of Fact, Conclu. of Law, and Order
Sequoia Energy US Inc.
Dante Tomassoni, Attorney

STATE OF NORTH DAKOTA

BEFORE THE NORTH DAKOTA PUBLIC SERVICE COMMISSION

In the matter of the Siting Application of
Sequoia Energy US Inc. for the 150 MW Border
Winds Energy Project, Rolette County, North
Dakota

Case No. PU-08-797

**PETITION FOR MODIFICATION OR
AMENDMENT OF FINDINGS OF FACT,
CONCLUSIONS OF LAW, AND ORDER
GRANTING CERTIFICATE OF SITE
COMPATIBILITY**

INTRODUCTION

Border Winds Energy, LLC ("Border Winds Energy") respectfully submits this Petition for Modification or Amendment of the Findings of Fact, Conclusions of Law and Order dated May 5, 2011 (the "Order"), and the corresponding Certificate of Site Compatibility for Energy Conversion Facility, Certificate Number 21, Case No. PU-08-797 (the "Certificate") issued to Sequoia Energy US Inc. ("Sequoia")¹ for the approximately 150 MW Border Winds Energy Project located in Rolette County, North Dakota (the "Project").

Since the North Dakota Public Service Commission (the "Commission") issued the Order and granted the Certificate for the Project, Border Winds Energy has continued to advance the project toward construction, including arranging off-take for the Project by way of a purchase and sale agreement with Northern States Power Company d/b/a Xcel Energy ("Xcel Energy").² Due to significant changes in turbine technology, turbine availability, and other market forces that took place during the course of the advancement of the Project, adjustments to the Project design became necessary; namely, a wind turbine generator other than that specified in the Order has been selected for the Project, as well as a corresponding revision to the turbine layout for the Project. Accordingly, Border Winds Energy hereby requests Commission approval of two modifications to the Order, as described further herein, to authorize: (1) use of the alternative

¹ Border Winds Energy and Sequoia filed concurrently with this petition an application for transfer of the Certificate of Site Compatibility from Sequoia to Border Winds Energy. Border Winds Energy respectfully requests that the Commission act on this petition and the petition for transfer of the Certificate together.

² On August 9, 2013, Xcel Energy filed an application for Advance Determination of Prudence (Case No. PU-13-742) and an application for Public Convenience and Necessity (Case No. PU-13-743) related to the Border Winds Project.

wind turbine model and associated towers and rotors, and (2) the alternative turbine layout for the Project.³

AMENDMENT REQUEST

As specified in Paragraphs 1 and 8 of the Findings of Fact in the Order, the Project was to consist of up to sixty-six Siemens 2.3 MW wind turbines totaling approximately 150 MW of generating capacity, and each such turbine was to have an 80 meter (262.5 foot) hub height and a 101 meter (331.4 foot) rotor diameter. Border Winds Energy has now identified a different wind turbine generator for the Project: the Vestas V100 2.0 MW wind turbine generator on 95 meter (311.7 foot) towers with a rotor diameter of 100 meter (328.1 feet). The Vestas V100 begins operations at wind speeds of 3 meters per second and reach a rated capacity of 2.0 MW at 16 meters per second. To maintain appropriate turbine spacing and other setbacks, this change in the wind turbine generator also requires revision to the turbine layout. The revised turbine layout is included as Attachment 1.

To permit these changes to the Project, Border Winds Energy requests the Commission amend the following in the Order:

Findings of Fact

Paragraph 2 of the Findings of Fact should be amended to read as follows:

Sequoia proposes to construct the Border Winds Energy Project, consisting of up to ~~66~~ 75 wind turbines totaling approximately 150 MW of generating capacity and associated facilities in Rolette County, North Dakota.

Paragraph 8 of the Findings of Fact should be amended to read as follows:

Sequoia plans to use ~~Siemens 2.3~~ Vestas V100 2.0 MW turbines. These are utility grade wind turbines with a nominal nameplate rating of ~~2300~~ 2000 kW. Each turbine will have an ~~80~~95 meter (~~262.5~~311.7 foot) hub height and a ~~101~~100 meter (~~331.4~~328.1 foot) rotor diameter. The turbines begin operations at wind speeds of ~~4.0~~ 3.0 meters per second (~~8.96~~6.7 miles per hour) and reach a rated capacity of ~~2.3~~ 2.0 MW at a wind speed of 16 meters per second (~~29.1 to 31.3~~ 36 miles per hour).

Paragraph 9 of the Findings of Fact should be amended to read as follows:

³ Border Winds Energy has already received approval of the revised wind turbine generator and turbine layout from the Rolette County Planning Committee and Board of Commissioners. The Rolette County Conditional Use Permit and Building Permit for the Project were issued on November 19, 2013 based on the revised wind turbine generator and turbine layout.

Each turbine is designed to operate at wind speeds of up to ~~25~~ 20 meters per second (~~55.9~~ 44.7 miles per hour) and can withstand wind speeds of over 55 meters per second (123.0 miles per hour).

Order

Paragraph 3 of the Order should be amended to read as follows:

Within the permitted area, Sequoia is authorized to site and construct up to ~~66~~75 wind turbines totaling approximately 150 MW of generating capacity in proposed and alternative locations....

The Commission has authority to amend the Certificate and Order pursuant to North Dakota Century Code Chapters 49-05 and 49-22. North Dakota law specifies that an “application for an amendment of a certificate shall be in such form and contain such information as the commission shall prescribe.”⁴ The Commission’s rules do not specify any such form or content for amendment provisions.⁵ Sequoia agreed in its October 15, 2009 Certification Relating to Order Provisions – Winder Energy Conversion Facility Siting (the “Company Certification”), which was incorporated by reference in the Order, to inform the Commission in writing of any modifications to the site plan and that any such modification must be approved in writing by the Commission or Commission staff after notice and opportunity for hearing.⁶ Thus, Border Winds Energy submits this petition as written notice to Commission pursuant to the Company Certification.

Amending these provisions as described above will enable Border Winds Energy to utilize the selected turbine, but will not otherwise change the terms and conditions of the Certificate, Order, or Company Certification, including provisions establishing setback, survey, and/or reporting requirements. The Project will continue to comply with all Order and Company Certification provisions. As such, the proposed amendment to the wind turbine generator, tower height, and turbine layout will not substantively change the Commission’s findings in its original Order approving the Certificate that the Project (1) will produce minimal adverse effects, (2) meets the site evaluation criteria, (3) is compatible with environmental preservation and the efficient use of resources, and (4) will minimize adverse human and environmental impact, while

⁴ N.D.CENT.CODE § 49-22-08(4).

⁵ See N.D.ADMIN.CODE §69-06-04.

⁶ Company Certification at P 35. The Commission previously approved an amendment involving the use of a different wind turbine, and in doing so followed a similar procedure, holding an informal hearing, providing the opportunity to comment, and issuing a notice of opportunity for hearing. See *In the Matter of Bison 1 Wind Project – Oliver/Morton Counties*, Amended Findings of Fact, Conclusions of Law and Order, Case No. PU-09-151 (Dec. 15, 2010).

ensuring continuing system reliability and integrity and ensuring that energy needs are met and fulfilled in an orderly and timely fashion.⁷

To support the proposed amendment and verify that the Commission's conclusions in the Order also apply based on the proposed amendment, Border Winds Energy conducted additional modeling and surveying based on the new wind turbine and associated turbine layout. First, Border Winds Energy completed sound and shadow flicker modeling for the proposed Vestas turbine. Reports detailing this modeling are included as Attachments 2 and 3 to this Petition, respectively. As the modeling reports indicate, there are no relevant sound or shadow flicker requirements under North Dakota state or Rolette County law. These analyses have been conducted in accordance with industry best practice and did not identify any areas of concern.

Additionally, Border Winds Energy evaluated the revised turbine locations for potential impacts to cultural resources and wetlands. Reports on these additional surveys are currently being prepared. Cultural resource surveys conducted on the revised turbine layout identified no cultural resources or impacts. Wetland impacts associated with the Project were originally coordinated with the U.S. Army Corps of Engineers (Corps) in 2010. At that time, the layout of the Project involved enough wetland impact to require permits from the Corps, and compensatory mitigation of wetlands through construction of new wetlands within the Project area. Since that time, the Project team redesigned the Project layout to significantly reduce overall wetland impacts from the Project. Based on the wetlands survey for the revised layout, wetlands impacts for the redesigned Project are anticipated to be primarily temporary impacts for collection lines and road widening, with some minor, permanent impacts for access road construction.

Because the revised turbine layout is located entirely within the Project boundary previously studied for potential human and environmental impacts and because the Project will comply with all setbacks and layout restrictions in the Order and Company Certification, the proposed amendment will not result in any impacts to resources not already considered by the Commission. Additionally, all pre-construction and construction survey, reporting, and administrative compliance obligations set forth in the Order and the Company Certification remain unchanged by the proposed amendment and will be met by Border Winds Energy.⁸ Consequently, the Project will continue to meet regulatory criteria and be compatible with the Order.

⁷ Order at Conclusions of Law PP 3-7 (citing N.D.CENT.CODE §49-22-05.2).

⁸ As part of the application for transfer of the Certificate to Border Winds Energy, Border Winds Energy agreed to assume all the rights and obligations of Sequoia under the Certificate, Order, and Company Certification.

CONCLUSION

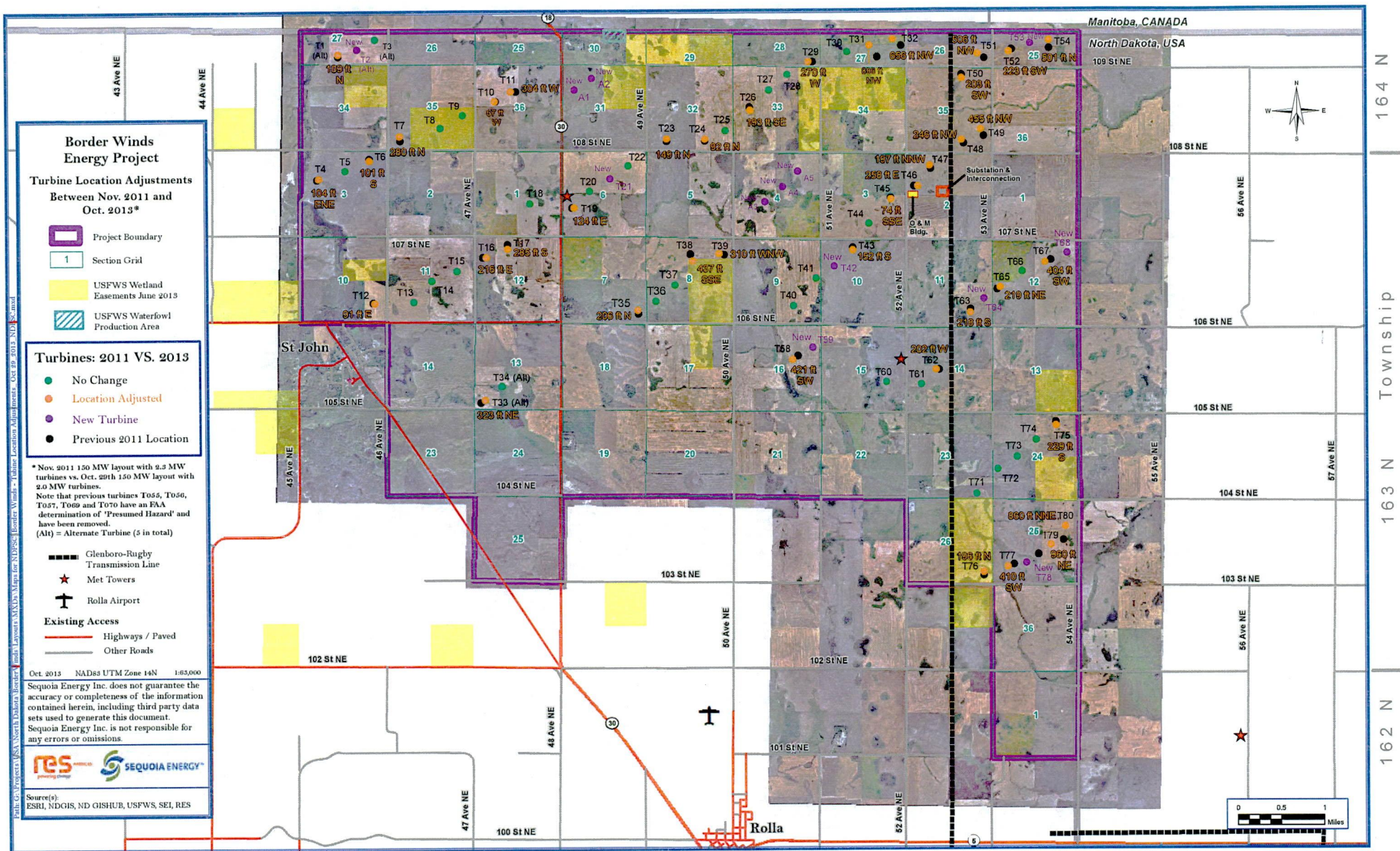
For the reasons set forth herein, Border Winds Energy respectfully requests that the Commission grant the proposed amendment to the Order for the Project to permit the use of the selected wind turbine generator and the revised turbine layout.

Dated: January 8, 2014

Respectfully submitted,



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70 W

69 W Range

164 N
Township
163 N
162 N

SOUND MODELING ASSESSMENT

**BORDER WINDS WIND FARM,
ROLETTE COUNTY, NORTH DAKOTA**

Client	Border Winds Energy, LLC
Contact	Sean Flannery
Document No.	702500-USPO-R-02
Issue	A
Status	Final
Classification	Client's Discretion
Date	20 November 2013

Author



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REVISION HISTORY

Issue	Issue Date	Summary
A	20 November 2013	Final

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1 INTRODUCTION

Border Winds Energy, LLC has requested Garrad Hassan America, Inc. ("GL GH") perform Environmental and Permitting Services including a sound modeling assessment for the Border Winds Wind Farm located in Rolette County, North Dakota, approximately 190 km northeast of Minot, ND. The Project consists of 75 Vestas V100-2.0 MW wind turbine generators and five alternate turbine locations at a hub height of 95 m and a rotor diameter of 100 m.

These turbines can have an effect on the sound levels experienced at receptors in the vicinity of the site. Sound impacts from a Project substation are also included. The objective of this assessment is to predict the sound levels generated by the Project's wind turbine generators and substation transformer at all receptors using the ISO 9613-2 method [1].

This report includes an explanation of environmental sound, a brief description of the Project site, an overview of the sound assessment methodology, results of the analysis including a map showing sound pressure levels at each receptor, and concluding comments.

2 ENVIRONMENTAL SOUND BACKGROUND

Sound levels are expressed in the decibel unit and are quantified on a logarithmic scale to account for the large range of acoustic pressures to which the human ear is exposed. A decibel (dB) is used to quantify sound levels relative to a 0 dB reference. The reference level of 0 dB is defined as a sound pressure level of 20 micropascals (μPa), which is the typical lower threshold of hearing for humans.

Sound levels can be presented both in broadband (sound energy summed across the entire audible frequency spectrum) and in octave band spectra (audible frequency spectrum divided into bands). Frequency is expressed in the Hertz unit (Hz), measuring the cycles per second of the sound pressure waves. The audible range of humans spans from 20 to 20,000 Hz. Since the human ear does not perceive every frequency with equal loudness, spectrally varying sounds are often adjusted with a weighting filter. The A-weighting filter is applied to closely approximate the human ear's response to sound. This scale is commonly used in environmental and industrial sound. Sound expressed in the A-weighted scale is denoted dBA.

A sound source has a certain sound power level (PWL) rating which describes the amount of sound energy per unit of time. This is a basic measure of how much acoustical energy it can produce and is independent of its surroundings. Sound pressure is created as sound energy flows away from the source. The measured sound pressure level (SPL) at a given point depends not only on the power rating of the source and the distance between the source and the measurement point (geometric divergence), but also on the amount of sound energy absorbed by environmental elements between the source and the measurement point (attenuation). Sound attenuation factors include meteorological conditions such as wind direction, temperature, and humidity; sound interaction with the ground; atmospheric absorption; terrain effects; diffraction of sound around objects and topographical features; and foliage.

3 APPLICABLE REGULATIONS

There are no applicable sound regulations in the state of North Dakota or in Rolette County.

4 DESCRIPTION OF THE WIND FARM SITE

4.1 Site Description

The site is located in northern North Dakota, approximately 190 km northeast of Minot, North Dakota, and near the Canadian border with the province of Manitoba. The proposed wind farm is situated in simple terrain, generally consisting of open farmland. Land cover on and near the site consists primarily of arable farmland interspersed with farmhouses and outbuildings surrounded by small wind breaks of deciduous trees. The site elevation ranges from 520 m to 585 m.

4.2 Wind Farm Layout

The proposed turbine layout, which consists of 75 Vestas V100-2.0 MW wind turbine generators, five alternate turbine locations, and one substation transformer, has been provided by the Client [2][3]. The coordinates of each Project turbine and the substation transformer are presented in Appendix A.

4.3 Receptor Locations

A list of 62 sound receptors has been provided by the Client [2]. All of the 62 receptors provided by the Client are included in this study. The ID numbers and coordinates of these receptors are listed in Appendix B.

5 SOUND ASSESSMENT

5.1 Description of the Sound Source

The sources of sound considered in this analysis are the Project wind turbine generators and one substation transformer. Sound associated with construction activities and other sources of sound in the vicinity of the Project have not been considered.

Broadband sound power levels, octave band distributions, and uncertainty levels for the Vestas V100-2.0 MW wind turbine generators at a hub height of 95 m were provided by the Client [4]. This acoustic emissions data was determined in accordance with the IEC 61400-11 standard [5]. At the specific request of the Client, an uncertainty level of 2 dBA was conservatively added to the maximum wind turbine acoustic emission levels in this analysis.

The maximum wind turbine acoustic emissions at standard setting (no sound restriction control mode) plus the 2 dBA uncertainty level is considered in this assessment and is presented in Table 5-1 for the Vestas V100-2.0 MW.

Table 5-1: Wind turbine acoustic emission summary

Frequency [Hz]	31.5	63	125	250	500	1000	2000	4000	8000	Broadband
Sound Power Level [dBA]	77.5	86.7	93.1	97.2	99.7	101.6	101.1	97.2	86.4	107.0

For the substation transformer, a sound power level of 106.6 dBA based on standard NEMA TR.1 Table 0-1 [6] for one 175 MVA, 230 kV transformer, and typical octave band distributions were taken, as shown in Table 5-2 below.

Table 5-2: Transformer acoustic emission summary

Frequency [Hz]	31.5	63	125	250	500	1000	2000	4000	8000	Broadband
Sound Power Level [dBA]	63.8	83.0	95.1	97.6	103.0	100.2	96.4	91.2	82.1	106.6

5.2 Assessment Methodology

The sound pressure level (SPL) at each receptor for the aggregate of all wind turbine generators and the transformer associated with the Border Winds Wind Farm was calculated based on the ISO 9613-2 method [1]. The simulation was run for the wind speed corresponding with the maximum sound power level (PWL) of the turbines and the maximum sound power level of the transformer (considering octave band sound levels), the hub height of the turbines, a height of 3 m above ground level (AGL) for the transformer, and a receptor height of 1.5 m.

The ISO 9613 standard provides a prediction of the equivalent continuous sound pressure level at a distance from one or more point sources. The method consists of octave-band algorithms (i.e., with nominal mid-band frequencies from 31.5 Hz to 8 kHz) for calculating the attenuation of the emitted sound. The algorithm takes into account the following physical effects:

- Geometrical divergence – attenuation due to spherical spreading from the sound source
- Atmospheric absorption – attenuation due to absorption by the atmosphere
- Ground effect – attenuation due to the acoustical properties of the ground

The ISO 9613 standard calculates attenuation under meteorological conditions favorable to propagation from sources of sound emission. These conditions are for downwind propagation or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as it commonly occurs at night. In other words, though a physical impracticality, the ISO 9613-2 standard treats every receptor as being downwind from every source of sound emission (in this case, turbines and transformers).

The ISO 9613-2 standard accounts for ground effect by assigning a numerical coefficient (G) with a value ranging from 0 to 1. A $G = 0$ equates to hard ground (paving, water, ice, concrete, tamped ground, and other ground surfaces with a low porosity), while a $G = 1$ equates to porous ground (ground covered by grass, trees, or other vegetation, and other ground surfaces suitable for the growth of vegetation such as farming land). Though the land cover at the Project site is primarily farm land, a mixed (semi-reflective) overall ground factor of $G = 0.7$ was used in this assessment.

Additionally, temperature, barometric pressure, and humidity parameters were selected to represent conditions favorable to sound propagation, and topographical information (official United States Geological Survey (USGS) digital elevation dataset) to accurately represent terrain in three-dimensions was included in this assessment.

Specifically, the ISO 9613-2 parameters were set as follows:

- Ambient air temperature: 10°C
- Ambient barometric pressure: 101.32 kPa
- Humidity: 70%
- Global ground factor: 0.7
- Topography included

Additional attenuation from foliage was not considered in this assessment, implying that the lower sound levels are expected in areas where there is foliage present in the line of sight between any turbine and a sound receptor. Similarly, because the model assumes every receptor is downwind of every sound source at all times, lower sound levels are expected at times when a receptor is upwind of any sound source.

The wind turbine sound emission ratings used for each octave band were those specified in Table 5-1. The sound impact was calculated for each receptor.

6 RESULTS

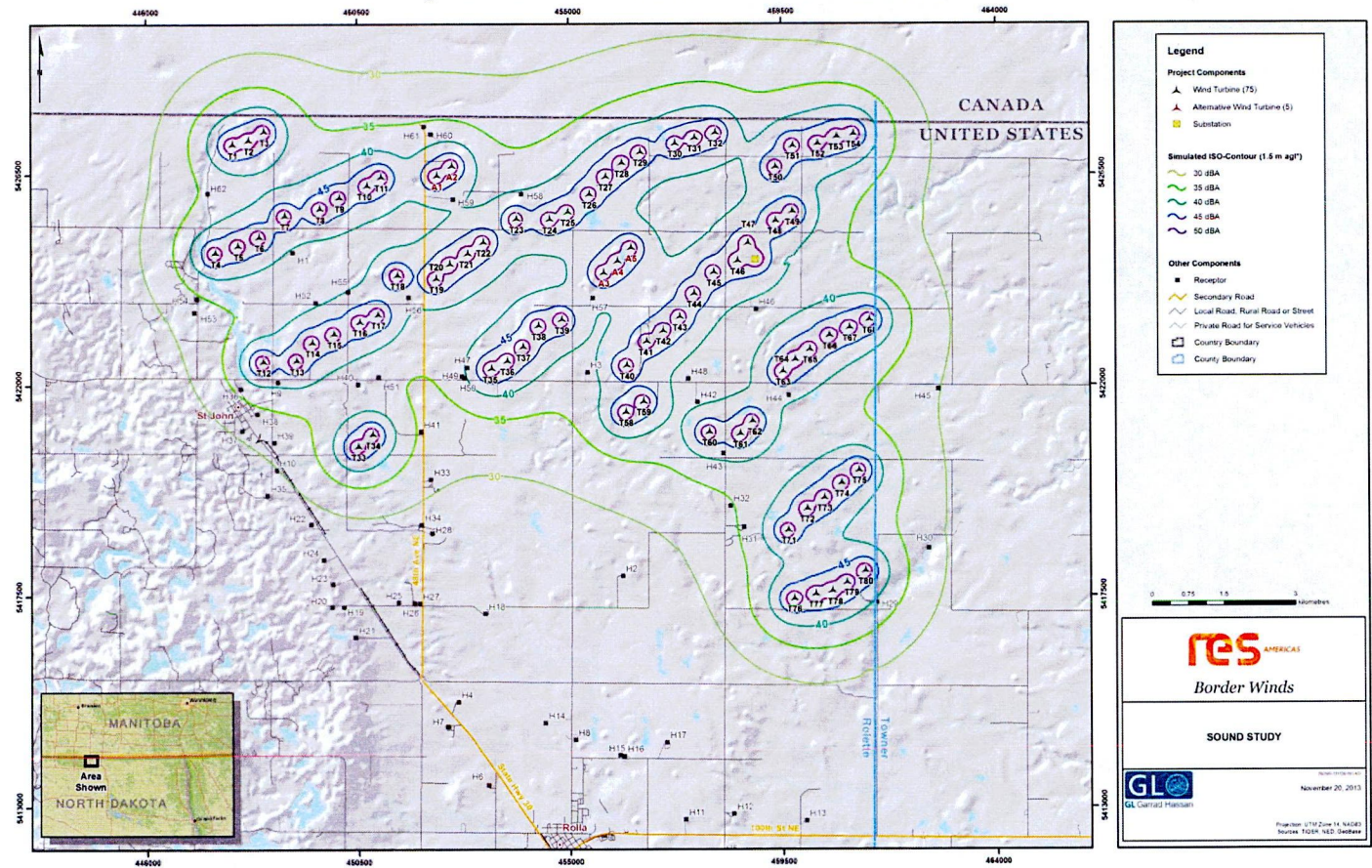
A map illustrating predicted A-weighted sound levels at receptors located in the vicinity of the Border Winds Wind Farm is presented in Figure 6-1.

The results of the sound study are presented for all sound receptors in tabular format in Appendix B. For each receptor, the following information is provided:

- ID;
- Coordinates;
- The sound level in dBA at the receptor location at 1.5 m;
- The distance to the closest wind turbine or transformer;
- The ID of the closest wind turbine or transformer.

Sound pressure levels at the 62 receptors range from 19.0 dBA to 42.2 dBA.

Figure 6-1: Modeled sound levels at 1.5 m at Border Winds Wind Farm



7 CONCLUSION

An analysis has been conducted to determine the maximum sound levels likely to be experienced at sound receptors in the vicinity of the Border Winds Wind Farm in Rolette County, North Dakota. This analysis was undertaken specifically for the Vestas V100-2.0 MW wind turbine generator at a hub height of 95 m.

As there are no sound relevant sound requirements under North Dakota state or Rolette County law, this analysis has been conducted in accordance with industry best practice.

8 REFERENCES

- [1] International Organization for Standardization. ISO 9613-2: Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation. 15 December 1996.
- [2] Turbine and receptor locations sent by email, S. Flannery, Border Winds Energy, LLC, to E. Crivella, GL GH, 16 October 2013, "Border Winds – GLGH Noise and Shadow Flicker Data Package.zip"
- [3] Substation information sent by email, S. Flannery, Pleasant Valley Wind, LLC, to K. Kallevig-Childers, GL GH, 8 November 2013, "23053D4001_SubstationSingleline.pdf"
- [4] Turbine noise emissions document sent by email, S. Flannery, Pleasant Valley, LLC, to E. Crivella, GL GH, 30 October 2013, "V100-2.0 MW Octave Banks.xlsx"
- [5] International Electrotechnical Commission. IEC 61400-11 Wind Turbine Generator Systems – Part 11: Acoustic Measurement Techniques. 07 November 2012.
- [6] National Electrical Manufacturers Association. NEMA Standards Publication No TR 1-1993 (R2000): Transformers, Regulators, and Reactors. 2000.

APPENDIX A**WIND TURBINE GENERATOR AND TRANSFORMER LAYOUT**

Turbine	Easting [m]¹	Northing [m]¹
T 1	447836	5426916
T 2	448180	5427006
T 3	448510	5427193
T 4	447465	5424601
T 5	447955	5424751
T 6	448401	5424938
T 7	448963	5425392
T 8	449711	5425539
T 9	450123	5425775
T 10	450714	5426031
T 11	451011	5426214
T 12	448487	5422277
T 13	449207	5422298
T 14	449541	5422686
T 15	450007	5422869
T 16	450552	5423125
T 17	450940	5423279
T 18	451356	5424121
T 19	452172	5424044
T 20	452461	5424352
T 21	452841	5424581
T 22	453177	5424821
T 23	453891	5425319
T 24	454593	5425309
T 25	454976	5425467
T 26	455433	5425844
T 27	455779	5426222
T 28	456119	5426512
T 29	456509	5426745
T 30	457244	5426930
T 31	457657	5427047
T 32	458093	5427156

Turbine	Easting [m]¹	Northing [m]¹
T33	450515	5420464
T34	450821	5420719
T35	453343	5422125
T36	453677	5422290
T37	454030	5422590
T38	454359	5423040
T39	454848	5423172
T40	456216	5422194
T41	456639	5422706
T42	456985	5422934
T43	457331	5423230
T44	457637	5423726
T45	458054	5424180
T46	458561	5424422
T47	458780	5424803
T48	459378	5425278
T49	459731	5425477
T50	459380	5426427
T51	459741	5426878
T52	460264	5426924
T53	460662	5427074
T54	461014	5427131
T58	456194	5421195
T59	456570	5421418
T60	457950	5420770
T61	458604	5420731
T62	458878	5421003
T63	459524	5422062
T64	459780	5422319
T65	460084	5422531
T66	460498	5422827
T67	460921	5422994
T68	461336	5423166
T71	459626	5418673

Turbine	Easting [m]¹	Northing [m]¹
T 72	460022	5419132
T 73	460384	5419364
T 74	460742	5419678
T 75	461113	5419950
T 76	459749	5417210
T 77	460198	5417308
T 78	460543	5417378
T 79	460848	5417552
T 80	461239	5417804
Alt 1	452191	5426241
Alt 2	452509	5426452
Alt 3	455733	5424173
Alt 4	456024	5424415
Alt 5	456306	5424704
T transformer	458973	5424473

1. Coordinates given in UTM Zone 14N, NAD 83 Datum.

APPENDIX B RECEPTOR LOCATIONS AND ASSOCIATED SOUND LEVELS

Receptor	UTM Coordinates		Calculated Sound Pressure Level [dBA]	Closest turbine	
	Easting [m] ¹	Northing [m] ¹		Distance [m]	ID
H56	451586	5423661	42.2	514	T18
H43	458237	5420324	41.9	530	T60
H44	459636	5421567	41.7	508	T63
H57	455494	5423646	41.3	579	A3
H09	448799	5421854	41.3	526	T12
H59	452533	5425752	41.0	700	A2
H58	453995	5425871	40.9	562	T23
H47	452817	5422159	40.4	527	T35
H55	450302	5423783	40.1	704	T16
H01	449123	5424624	39.5	784	T7
H29	461466	5417142	39.4	700	T80
H42	457699	5421418	39.3	695	T60
H52	449611	5423557	39.2	794	T15
H50	452763	5421948	39.1	606	T35
H46	458949	5423405	38.9	1068	Transfo
H48	457504	5421922	38.6	1061	T59
H03	455381	5422064	38.6	845	T40
H49	452704	5421974	38.5	657	T35
H60	452064	5427149	37.4	827	A2
H40	450506	5421810	37.1	1136	T34
H51	450941	5421965	36.6	1223	T16
H36	448008	5421717	36.3	737	T12
H62	447302	5425892	35.8	1155	T1
H61	451919	5427310	35.7	1041	A2
H31	458669	5418754	35.7	960	T71
H32	458385	5419208	34.6	1351	T71
H41	451838	5420796	34.5	1020	T34
H54	447068	5423640	34.2	1040	T4
H38	448351	5421184	33.7	1101	T12
H53	447013	5423349	32.6	1331	T4
H30	462561	5418295	31.8	1410	T80
H39	448720	5420567	31.5	1726	T12

Receptor	UTM Coordinates		Calculated Sound Pressure Level [dBA]	Closest turbine	
	Easting [m] ¹	Northing [m] ¹		Distance [m]	ID
H33	452041	5419774	31.2	1543	T34
H37	448026	5420818	30.8	1530	T12
H45	462775	5421692	30.2	2060	T68
H10	448765	5419980	29.8	1816	T33
H34	451845	5418804	28.4	2127	T33
H22	449501	5418819	28.0	1932	T33
H35	448563	5419437	27.8	2206	T33
H28	452072	5418628	27.7	2407	T33
H02	456112	5417710	27.4	3486	T58
H24	449769	5418064	26.0	2513	T33
H23	449963	5417544	24.9	2972	T33
H27	451802	5417125	24.6	3578	T33
H26	451691	5417133	24.6	3532	T33
H25	451359	5417150	24.6	3420	T33
H18	453192	5416908	24.5	4451	T33
H19	450198	5417053	23.9	3426	T33
H20	449947	5417053	23.8	3458	T33
H17	457027	5414158	23.2	4089	T76
H21	450442	5416406	23.1	4059	T33
H16	456131	5413866	22.2	4927	T76
H14	454470	5414574	22.2	5901	T76
H15	456043	5413886	22.2	4978	T76
H08	455103	5414213	22.1	5529	T76
H04	452612	5415021	22.0	5833	T33
H12	458441	5412636	21.6	4757	T76
H13	459980	5412488	21.6	4728	T76
H07	452393	5414495	21.4	6257	T33
H11	457421	5412516	21.1	5240	T76
H06	453257	5413245	20.4	7607	T76
H05	458198	5411744	19.0	5682	T76

1. Coordinates given in UTM Zone 14N, NAD 83 Datum.



**SHADOW FLICKER ASSESSMENT
BORDER WINDS WIND FARM,
ROLETTE COUNTY,
NORTH DAKOTA**

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1 INTRODUCTION

Border Winds Energy, LLC ("Client") has requested that Garrad Hassan America, Inc. ("GL GH") provide Environmental and Permitting services, including assessment of the impact of the shadow flicker effects in the vicinity of the proposed Border Winds Wind Farm (the "Project"). The proposed Border Winds Wind Farm is located in Rolette County, approximately 190 km northeast of Minot, ND. The wind farm consists of 75 turbines and five alternative turbine locations at a hub height of 95 m and a rotor diameter of 100 m.

These turbines can have an influence on the shadow flicker experienced at sensitive locations in the vicinity of the site. The purpose of this shadow flicker analysis is to calculate the predicted shadow flicker duration from the proposed Project at several receptor locations. This report includes a brief presentation of the Project site, a description of the shadow flicker assessment methodology, results of the analysis including a map illustrating areas prone to shadow flicker, and concluding comments.

1.1 Shadow Flicker Definition

Shadow flicker is defined as the modulation of light levels resulting from the periodic passage of a rotating wind turbine blade between the sun and a viewer. The duration of shadow flicker experienced at a specific location can be determined using a purely geometric analysis which takes into account the relative positions of the sun throughout the year, the wind turbines at the site, and the viewer. This method has been used to determine the shadow flicker duration at sensitive locations in proximity to the Project.

It should be noted, as described in Section 3.3, that there are several simplifications and conservative assumptions inherent within the model which may result in an overestimate of shadow flicker duration.

2 DESCRIPTION OF THE WIND FARM SITE

2.1 Site Description

The site is located in northern North Dakota, approximately 190 km northeast of Minot, North Dakota, and near the Canadian border with the province of Manitoba. The proposed wind farm is situated in simple terrain, generally consisting of open farmland. Land cover on and near the site consists primarily of arable farmland interspersed with farmhouses and outbuildings surrounded by small wind breaks of deciduous trees. The site elevation ranges from 520 m to 585 m.

2.2 Wind Farm Layout

The proposed turbine layout, which consists of 75 Vestas V100-2.0 MW wind turbine generators and five alternate turbine locations, has been supplied by the Client [1]. The precise coordinates of each turbine are presented in Appendix A.

2.3 Receptor Locations

A list of receptors to be considered as shadow flicker receptors has been provided by the Client [2]. Shadow flicker duration is calculated for all 31 receptors that are located within 1,450 m (10 times the tip height, as explained in Section 3.2) of a turbine. The ID numbers and coordinates of these dwellings are listed in Appendix B.

2.4 Applicable Regulations

There are no applicable local or state requirements with regards to shadow flicker in Rolette County.

3 SHADOW FLICKER ASSESSMENT

3.1 Overview

Shadow flicker may occur under certain combinations of circumstances with regards to the sun's position and wind direction; when the sun passes behind the rotating blades of a wind turbine, a moving shadow is cast in front of or behind the turbine. When viewed from a stationary position, the moving shadows cause periodic flickering of the sunlight, otherwise known as the "shadow flicker" phenomenon.

The effect is most noticeable inside buildings, where the flicker appears through a window opening. The likelihood and duration of the effect depends on a number of variables, namely:

- Orientation of the building relative to the turbine;
- Wind direction: the shape and intensity of the shadow are determined by the position of the sun relative to the blades (the turbine rotor continuously yaws to face the wind so the rotor plane will always be perpendicular to the wind direction);
- Distance from turbine: the farther the observer from the turbine, the less pronounced the effect;
- Turbine height and rotor diameter: a larger turbine rotor diameter will cast a larger shadow, meaning a larger area will be prone to incidences of shadow flicker;
- Time of year and day: position of sun relative to the horizon;
- Weather conditions: cloud cover reduces the occurrence of shadow flicker;
- Vegetation and other obstacles that help to mask shadows;
- Operational status of turbines.

3.2 Assessment Methodology

The number of hours of shadow flicker experienced annually at a given location can be calculated using a geometrical model which takes into account the sun's position, topography of the wind farm site and wind turbine specifications such as rotor diameter and hub height.

The wind turbine has been modeled assuming all wind turbines are disc objects oriented perpendicular to the sun-turbine vector, representing the maximum duration for which there is potential for shadow flicker to occur.

Shadow flicker has been calculated at the subject receptors (i.e. residences) at a height of 2 m to represent ground floor windows. Rather than facing a particular direction, shadow flicker receptors (windows) are simulated as horizontal planes, meaning they experience shadow flicker over 360°; this assumption therefore represents a worst case scenario. Simulations have been carried out with a resolution of 1 minute; if shadow flicker occurs in any 1-minute period, the model registers this as 1 minute of shadow flicker.

It is generally accepted that shadow flicker from wind turbines does not occur beyond a distance, D , from a given wind turbine. The UK wind industry considers this distance to be equivalent to 10 rotor diameters [3], while the Danish wind industry suggests a value of between 500 and 1000 m [4]. GL GH has adopted a conservative approach and has assumed the length, D , that a shadow can be cast to be defined as follows:

$$D = 10 \times (\text{hub height} + \text{rotor radius})$$

Beyond this distance, a viewer does not perceive the turbine blade to be chopping the light, but rather as an object passing in front of the sun.

Shadow flicker calculations can be adjusted using an annual cloud coverage figure which is based on historical meteorological data and statistics. According to data gathered from meteorological stations, an annual cloud cover can be estimated and applied as a percentage. Further, using the site-specific wind rose to consider the probability of the turbines being oriented in a given direction could lead to significant further reduction in the annual shadow flicker occurrence.

No attempt has been made to account for vegetation or other shielding effects around each shadow receptor in the calculations of shadow flicker duration. Similarly, neither turbine operational shut-down nor the site specific wind rose have been considered in this analysis. Consideration of these factors could lead to a significant reduction of the levels of shadow flicker predicted.

3.3 Simplification and Conservative Assumptions

Shadow flicker duration calculated in the manner described above has several limitations and may over-estimate the annual number of hours of shadow flicker experienced at a specified location for several reasons, namely:

- The modeling of the wind turbine blades as discs rather than individual blades results in an overestimate of shadow flicker duration.

Turbine blades are of non-uniform thickness with the thickest part of the blade (maximum chord) close to the hub and the thinnest part (minimum chord) at the tip. Diffusion of sunlight, as discussed above, results in a limit to the maximum distance that a shadow can be perceived. This maximum distance will also be dependent on the thickness of the turbine blade and the human threshold for perception of light intensity variation. As such, a shadow cast by the blade tip will be shorter than the shadow cast by the thickest part of the blade [5].

- The wind turbine will not always be yawed such that its rotor is perpendicular to the sun-turbine vector. Any other rotor orientation will reduce the area of the projected shadow, and thus the incidence of shadow flicker. Additionally, the orientation of windows on a given house has not been taken into account, i.e. the model assumes that a window is always facing the turbine(s). The wind speed frequency distribution, or wind rose, at the site can be used to determine probable turbine orientation in order to calculate the resulting reduction in shadow flicker duration; however this has not been done in this study.
- Aerosols (moisture, dust, smoke, etc.) in the atmosphere have the ability to influence shadows cast by a wind turbine. The length of the shadow cast by a wind turbine is dependent on the degree that direct sunlight is diffused, which in turn is dependent on the amount of dispersants (humidity, smoke and other aerosols) in the path between the light source (sun) and the receiver [5].
- Modeling the sun as a point light source rather than a disc results in an overestimate of the shadow flicker duration. The fact that the light source is a disc results in a shadow which is less well defined and of lower intensity as compared to a point light source.
- The occurrence of cloud cover has the potential to significantly reduce the number of hours of shadow flicker.

Cloud cover measurements recorded at nearby meteorological stations may be used to estimate probable levels of cloud cover, and to provide an indication of the resulting reduction in shadow flicker duration (see Section 3.4).

- The presence of vegetation or other physical barriers around a shadow receptor location may shield the view of the wind turbine, and therefore reduce the incidence of shadow flicker.
- Periods where the wind turbine is not in operation due to low winds, high winds, or for operational and maintenance reasons will also reduce shadow flicker occurrence.

In light of the reasons listed above, it is likely that the shadow flicker durations presented in Section 4 can be regarded as conservative.

3.4 Current Analysis

The shadow flicker assessment for the proposed Project has been conducted for the 75 Vestas V100-2.0 MW turbines and five alternate turbine locations using the method described in Section 3.2. The wind turbines have been modeled assuming all wind turbines are disc objects oriented perpendicular to the sun-receptor vector, representing the maximum duration for which there is potential for shadow flicker to occur.

All receptors in Rolette County located distance D , defined in Section 3.2, have been included in the study. For the Vestas V100-2.0 MW wind turbine generator this equals 1,450 m.

In order to render more realistic shadow flicker results, cloud cover statistics have been considered. According to data gathered from the Brandon EC meteorological station, it has been estimated that the cloud cover is sufficient to nullify shadow flicker occurrence 58.3 % of the time.

The model does not take into account any obstacles; for example vegetation, mountains, or other shielding effects, around each shadow receptor in calculating the shadow flicker duration. Similarly, neither turbine operational shut-down nor the site-specific wind rose have been considered in this analysis. Consideration of these factors could lead to a significant reduction of the levels of shadow flicker predicted.

4 RESULTS

An analysis has been conducted to determine the duration of shadow flicker predicted for receptors in the vicinity of the Border Winds Wind Farm in ND. This analysis was undertaken specifically for the V100-2.0 MW wind turbine with a blade tip height of 145 m.

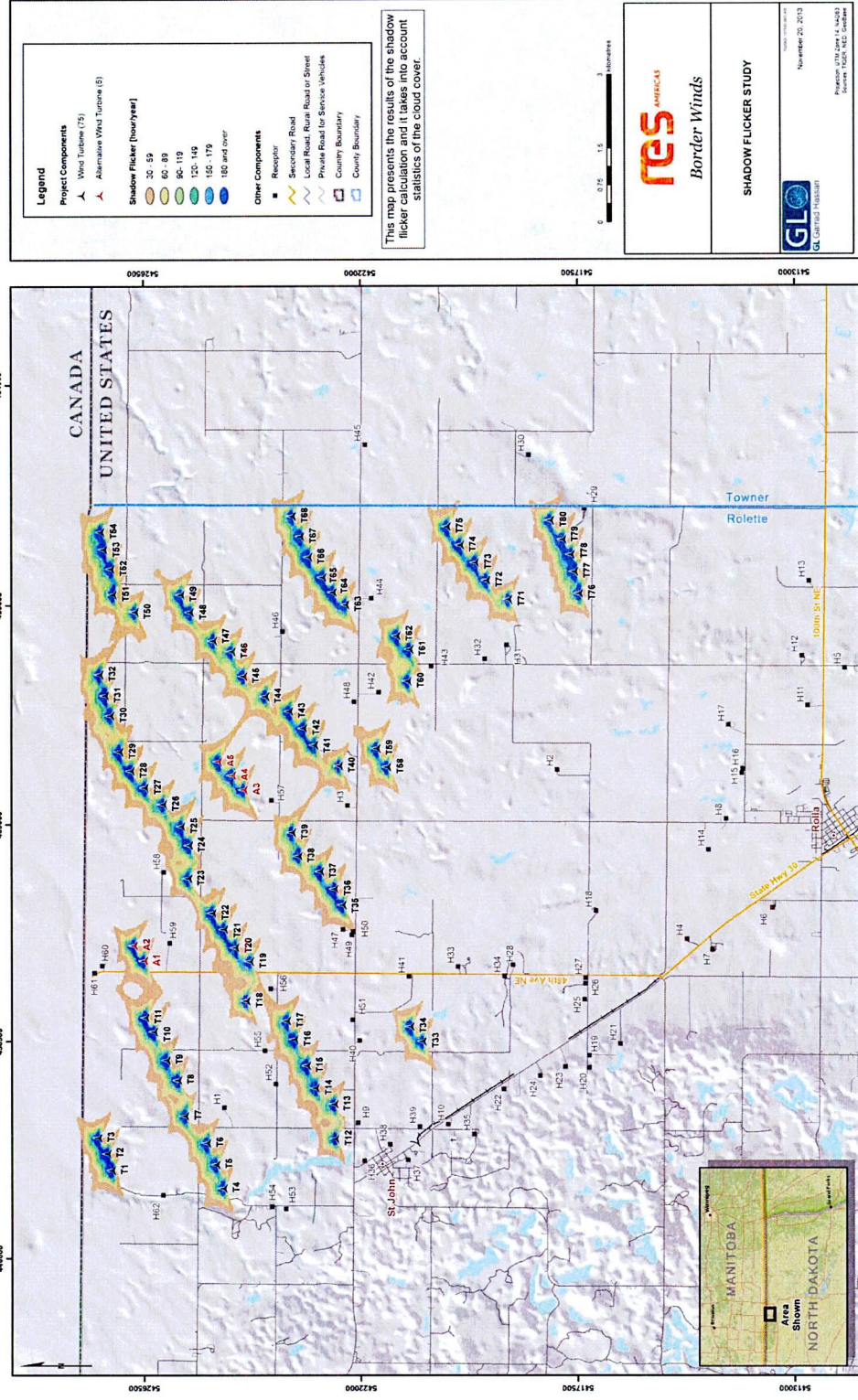
A map illustrating predicted shadow flicker duration at receptors in the vicinity of the Border Winds Wind Farm is presented in Figure 4-1. This map takes into account average annual cloud cover. For illustrative purposes shadow flicker is shown when occurring 30 hours or more per year.

The results of the shadow flicker assessment are presented for the 31 receptors that are located within 1,450 m of a turbine (in terms of maximum minutes per day and total hours per year) in tabular format in Appendix B.

The receptor that is predicted to experience the most hours of shadow flicker in one year is receptor H50. The predicted duration of shadow flicker at this receptor is 24 hours per year, taking into account cloud cover. Receptor H50 also has the highest predicted number of maximum minutes of shadow flicker in one day, with a total of 58 minutes predicted to occur on 24 July. Receptor H3 experiences the most anticipated days of flicker exposure at 170 days; however, the overall amount of exposure is anticipated to be 17 hours per year.

Results in hours per year take into account the cloud cover from the Environment Canada meteorological station at Brandon EC but, as described in Section 3.3, these results are still considered to be conservative.

Figure 4-1: Modeled hours of shadow flicker at Border Winds Wind Farm



5 CONCLUSION

An analysis has been conducted to determine the duration of shadow flicker to be experienced at receptors in the vicinity of the Border Winds Wind Farm in ND. This analysis was undertaken specifically for the Vestas V100-2.0 MW wind turbine with a blade tip height of 145 m.

The receptor that is predicted to experience the most hours of shadow flicker in one year is receptor H50. The predicted duration of shadow flicker at this receptor is 24 hours per year, taking into account cloud cover. Receptor H50 also has the highest predicted number of maximum minutes of shadow flicker in one day, with a total of 58 minutes predicted to occur on 24 July. Receptor H3 experiences the most anticipated days of flicker exposure at 170 days; however, the overall amount of exposure is anticipated to be 17 hours per year.

Detailed results for each of the 31 receptors that are located within 1,450 m of a turbine can be found in Appendix B. The duration experienced in hours per year takes into account average yearly cloud cover from the Environment Canada meteorological station at Brandon EC. Nevertheless as described in Section 3.3, several other conservative assumptions have been made in this analysis. Given that a shadow flicker analysis is not required under North Dakota or Rolette County regulations, this report is presented in accordance with industry best practice.

6 REFERENCES

- [1] Turbine locations sent by email, S. Flannery, Border Winds Energy, LLC., to E. Crivella, GL GH, 16 October 2013, "Border Winds – GLGH Noise & Shadow Flicker Data Package.zip."
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- [3] Department for Business Enterprise & Regulatory Reform, UK, "Onshore Wind: Shadow Flicker", <http://www.berr.gov.uk/whatwedo/energy/sources/renewables/planning/onshore-wind/shadow-flicker/page18736.html>, viewed 23 July 2010.
- [4] Danish Wind Industry Association, "Shadow variations from Wind turbines", <http://guidedtour.windpower.org/en/tour/env/shadow/shadow2.htm>, viewed 22 July 2010.
- [5] Freud H-D, Kiel F.H., "Influences of the opaqueness of the atmosphere, the extension of the sun and rotor blade profile on the shadow impact of wind turbine", DEWI Magazine No. 20 pp 43-51, Feb 2002.

APPENDIX A TURBINE LAYOUT

Turbine	Easting [m]¹	Northing [m]¹
T1	447836	5426916
T2	448180	5427006
T3	448510	5427193
T4	447465	5424601
T5	447955	5424751
T6	448401	5424938
T7	448963	5425392
T8	449711	5425539
T9	450123	5425775
T10	450714	5426031
T11	451011	5426214
T12	448487	5422277
T13	449207	5422298
T14	449541	5422686
T15	450007	5422869
T16	450552	5423125
T17	450940	5423279
T18	451356	5424121
T19	452172	5424044
T20	452461	5424352
T21	452841	5424581
T22	453177	5424821
T23	453891	5425319
T24	454593	5425309
T25	454976	5425467
T26	455433	5425844
T27	455779	5426222
T28	456119	5426512
T29	456509	5426745
T30	457244	5426930
T31	457657	5427047
T32	458093	5427156
T33	450515	5420464
T34	450821	5420719
T35	453343	5422125
T36	453677	5422290

Turbine	Easting [m] ¹	Northing [m] ¹
T37	454030	5422590
T38	454359	5423040
T39	454848	5423172
T40	456216	5422194
T41	456639	5422706
T42	456985	5422934
T43	457331	5423230
T44	457637	5423726
T45	458054	5424180
T46	458561	5424422
T47	458780	5424803
T48	459378	5425278
T49	459731	5425477
T50	459380	5426427
T51	459741	5426878
T52	460264	5426924
T53	460662	5427074
T54	461014	5427131
T58	456194	5421195
T59	456570	5421418
T60	457950	5420770
T61	458604	5420731
T62	458878	5421003
T63	459524	5422062
T64	459780	5422319
T65	460084	5422531
T66	460498	5422827
T67	460921	5422994
T68	461336	5423166
T71	459626	5418673
T72	460022	5419132
T73	460384	5419364
T74	460742	5419678
T75	461113	5419950
T76	459749	5417210
T77	460198	5417308
T78	460543	5417378
T79	460848	5417552

Turbine	Easting [m]¹	Northing [m]¹
T80	461239	5417804
A1	452191	5426241
A2	452509	5426452
A3	455733	5424173
A4	456024	5424415
A5	456306	5424704

1. Coordinate system is UTM Zone 14N, NAD83 datum.

APPENDIX B

RECEPTOR LOCATIONS AND ASSOCIATED SHADOW FLICKER

Receptor	UTM Coordinates		Number of days per year	Worst day	Max mins per day [min/day]	Total Hours in Year [hrs/yr]		Turbine ID contributing to the events	Closest turbine	
	Easting [m] ¹	Northing [m] ¹				without cloud cover	taking into account the cloud cover		Distance [m]	ID
H50	452763	5421948	84	24-Jul	58	57	24	T35 T36 T37	606	T35
H47	452817	5422159	104	11-Apr	56	51	21	T35 T36 T37	527	T35
H58	453995	5425871	127	8-Jan	30	44	18	T24 T25 T26	562	T23
H1	449123	5424624	118	18-Jul	32	43	18	T5 T6	784	T7
H3	455381	5422064	170	17-Apr	28	40	17	T37 T40 T41 T58 T59	845	T40
H49	452704	5421974	60	3-May	53	37	15	T35 T36	657	T35
H55	450302	5423783	92	25-Jan	30	31	13	T17 T18	704	T16
H56	451586	5423661	65	10-Feb	44	27	11	T16 T17 T19	514	T18
H57	455494	5423646	64	3-Nov	40	27	11	T38 T39	579	A3
H42	457699	5421418	94	22-Jan	23	21	9	T59 T61 T62	695	T60
H44	459636	5421567	74	13-Nov	27	21	9	T61 T62	508	T63
H29	461466	5417142	63	23-Apr	24	17	7	T77 T78	700	T80
H48	457504	5421922	58	8-Feb	23	14	6	T40 T59	1061	T59
H31	458669	5418754	54	23-Mar	23	13	5	T71 T72	960	T71
H60	452064	5427149	52	4-Dec	19	12	5	T11	827	A2
H52	449611	5423557	52	17-Feb	24	12	5	T16 T17	794	T15
H41	451838	5420796	50	21-Mar	23	12	5	T33 T34	1020	T34
H46	458949	5423405	57	20-Aug	18	10	4	T44 T65	1089	T46
H36	448008	5421717	39	22-May	18	8	3	T13	737	T12

Receptor	UTM Coordinates		Number of days per year	Worst day	Max mins per day [min/day]	Total Hours in Year [hrs/yr]		Turbine ID contributing to the events	Closest turbine	
	Easting [m] ¹	Northing [m] ¹				without cloud cover	taking into account the cloud cover		Distance [m]	ID
H40	450506	5421810	28	5-May	18	6	2	T13	1136	T34
H30	462561	5418295	22	21-Feb	18	4	2	T80	1410	T80
H32	458385	5419208	22	19-Feb	17	4	2	T71	1351	T71
H59	452533	5425752	20	28-Feb	15	3	1	T23	597	A1
H9	448799	5421854	-	-	-	-	-		526	T12
H43	458237	5420324	-	-	-	-	-		530	T60
H54	447068	5423640	-	-	-	-	-		1040	T4
H61	451919	5427310	-	-	-	-	-		1041	A2
H38	448351	5421184	-	-	-	-	-		1101	T12
H62	447302	5425892	-	-	-	-	-		1155	T1
H51	450941	5421965	-	-	-	-	-		1223	T16
H53	447013	5423349	-	-	-	-	-		1331	T4

1. Coordinate system is UTM Zone 14N, NAD83 datum.